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**REMARKS**

By the present amendment and response, claims 1, 21-22, and 29 have been amended to overcome the Examiner's objections. Claims 1-8 and 21-30 are pending in the present application. Reconsideration and allowance of pending claims 1-8 and 21-30 in view of the above amendments and the following remarks are requested.

**A. Rejection of Claim 1 under 35 USC §102(b)**

The Examiner has rejected claim 1 under 35 USC §102(b) as being anticipated by European patent application publication number EP 0 475 646 A2 to Saul et al. (hereinafter "Saul"). For the reasons discussed below, Applicants respectfully submits that the present invention, as defined by amended independent claim 1, is patentably distinguishable over Saul.

The present invention, as defined by amended independent claim 1, recites, among other things, forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, where the second capping layer is situated over the selected metal lines. As disclosed in the present application, metal lines are formed in a first capping layer and a first dielectric layer by forming

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trenches in the first capping layer and the first dielectric layer and filling the trenches with a metal, such as copper. As disclosed in the present application, a second capping layer is deposited over the metal lines and on first capping layer to serve as a dielectric barrier for the copper.

As disclosed in the present application, air gaps, i.e. air trenches, are formed between selected metal lines in the first dielectric layer. As a result, the present invention achieves an improved damascene interconnect structure that advantageously reduces parasitic capacitance between metal lines within the same metal layer (i.e. intra-layer capacitance). As disclosed in the present application, a second dielectric layer can be formed over the second capping layer and the air gaps, i.e. air trenches, can be formed in the second dielectric layer and the first dielectric layer. As a result, the present invention achieves an improved damascene interconnect structure that also advantageously reduces parasitic capacitance between metal lines in adjacent metal layers (i.e. inter-layer capacitance).

In contrast, Saul does not teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, where the second capping layer is situated over the selected metal

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lines. Saul specifically discloses depositing a first metallization layer on first dielectric layer 3 to form conductive tracks 4 and 5. See, for example, column 2, lines 56-58, column 3, lines 1-2, and Figures 2 and 3 of Saul. In Saul, second dielectric layer 6 is formed over the top of conductive tracks 4 and 5, on which is formed conductive tracks 7 and 8, and third dielectric layer 9 is formed over the top of conductive tracks 7 and 8. See, for example, column 3, lines 3-9 and Figures 2 and 3 of Saul.

In Saul, parts of dielectric layers 3, 6, and 9 are etched away to form air gaps 16 between the vertical stacks of conductive tracks 4, 7 and 5, 8. See, for example, column 3, lines 47-50 and Figure 3 of Saul. However, Saul fails to teach, disclose, or remotely suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, where the second capping layer is situated over the selected metal lines, as specified in amended independent claim 1. Furthermore, the structure disclosed in Saul does not comprise a damascene interconnect structure, as specified in amended independent claim 1. Thus, the structure disclosed by Saul is substantially different than the damascene interconnect structure as specified in amended independent claim 1.

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For the foregoing reasons, Applicants respectfully submit that the present invention, as defined by amended independent claim 1, is not taught, disclosed, or suggested by Saul. Thus, amended independent claim 1 is patentably distinguishable over Saul.

**B. Rejection of Claims 1-8 and 29-30 under 35 USC §102(e)**

The Examiner has rejected claims 1-8 and 29-30 under 35 USC §102(e) as being anticipated by U.S. patent number 6,184,121 B1 to Buchwalter et al. (hereinafter "Buchwalter"). For the reasons discussed below, Applicants respectfully submits that the present invention, as defined by amended independent claims 1 and 29, is patentably distinguishable over Buchwalter.

In contrast to the present invention as defined by amended independent claim 1, Buchwalter does not teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, where the second capping layer is situated over the selected metal lines. Buchwalter specifically discloses patterning and plasma etching dielectric layers 20 and 30, which are applied on a semiconductor substrate, to produce trenches 50 on the top

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layer that represent wiring tracks and vias 40, in the lower layer. See, for example, column 2, lines 1-4 and Figure 2A of Buchwalter. In Buchwalter, electrically conductive barrier/adhesion layer 60 and copper-based conductive layer 70 are deposited in trenches 50 and vias 40 so as to fill trenches 50 and vias 40, and a chemical-mechanical polishing process is used to planarize the top surface by removing excess copper and barrier layer material. See, for example, column 2, lines 8-19 and Figures 2B and 2C of Buchwalter.

In Buchwalter, the above process is repeated to build the necessary number of wiring layers. See, for example, Buchwalter, column 2, lines 20-21. In Buchwalter, air gaps are formed by etching portions of dielectric layers 20 and 30. See, for example, column 6, lines 53-60 and Figure 4A of Buchwalter. However, in Buchwalter, wiring tracks are formed only in dielectric layer 30, while vias 40 are formed in dielectric 20. Thus, Buchwalter fails to teach, disclosure, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer and filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, as specified in amended independent claim 1.

For the foregoing reasons, Applicants respectfully submit that the present invention, as defined by amended independent claim 1, is not taught, disclosed, or suggested by Buchwalter. Thus, amended independent claim 1 is patentably distinguishable over Buchwalter. As such, claims 2-8 depending from amended independent claim 1 are, *a fortiori*, also patentably distinguishable over Buchwalter for at

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least the reasons presented above and also for additional limitations contained in each dependent claim.

Amended independent claim 29 includes similar limitations as amended independent claim 1 discussed above. Thus, for the reasons discussed above, Applicant respectfully submits that the present invention, as defined by amended independent claim 29, is not suggested, disclosed, or taught by Buchwalter. Thus claim 30 depending from amended independent claim 29 is, *a fortiori*, also patentably distinguishable over Buchwalter for at least the reasons presented above and also for additional limitations contained in the dependent claim.

**C. Rejection of Claims 1 and 4-8 under 35 USC §102(e)**

The Examiner has rejected claims 1 and 4-8 under 35 USC §102(e) as being anticipated by U.S. patent number 6,159,840 to Jyh-Ming Wang (hereinafter "Wang"). For the reasons discussed below, Applicants respectfully submits that the present invention, as defined by amended independent claim 1, is patentably distinguishable over Wang.

In contrast to the present invention as defined by amended independent claim 1, Wang does not teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a

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second capping layer directly on the first capping layer, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, where the second capping layer is situated over the selected metal lines. Wang specifically discloses forming metal layer 202 on substrate 200 as the bottom layered conductive line of a metal interconnect. See, for example, column 2, lines 49-51 and Figure 2A of Wang.

In Wang, dielectric layer 204 is formed covering metal layer 202 and substrate 200 and stop layer 206 is formed on dielectric layer 205. See, for example, column 2, lines 51-56 and Figure 2A of Wang. As shown in Figures 2B and 2C of Wang, air gap 213 is formed in etch stop layer 206 and dielectric layer 204. Thus, in Wang, metal layer 202 is situated in dielectric layer 204 and, consequently, not formed in a first capping layer and a first dielectric layer, as specified in amended independent claim 1.

Furthermore, Wang fails to teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, depositing a second capping layer directly on the first capping layer, where the second capping layer is situated over the selected metal lines, as specified in amended independent claim 1.

For the foregoing reasons, Applicants respectfully submit that the present invention, as defined by amended independent claim 1, is not taught, disclosed, or suggested by Wang. Thus, amended independent claim 1 is patentably distinguishable over Wang. As such, claims 4-8 depending from amended independent claim 1 are, a

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*fortiori*, also patentably distinguishable over Wang for at least the reasons presented above and also for additional limitations contained in each dependent claim.

**D. Rejection of Claims 21-28 under 35 USC §103(a)**

The Examiner has rejected claims 21-28 under 35 USC §103(a) as being unpatentable over Buchwalter in view of U.S. patent number 5,708,303 to Shin-Puu Jeng (hereinafter "Jeng"). For the reasons discussed below, Applicants respectfully submits that the present invention, as defined by amended independent claim 21, is patentably distinguishable over Buchwalter and Jeng, singly or in combination thereof.

The present invention, as defined by amended independent claim 21, recites, among other things, forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer and over the plurality of spaced-apart metal lines, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines. The present invention, as defined by amended independent claim 21, provides similar advantages as the present invention as defined by amended independent claim 1 as discussed above.

For similar reasons as discussed above, Buchwalter fails to teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer,



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filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer and over the plurality of spaced-apart metal lines, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines.

In contrast to the present invention as defined by amended independent claim 21, Jeng does not teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer and over the plurality of spaced-apart metal lines, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines. The Examiner has cited Jeng to disclose that it is well known in the art to deposit an etch stop layer directly on a polish stop layer. Page 8 of the Office Action dated November 18, 2004.

However, Jeng fails to teach, disclose, or suggest forming a plurality of trenches in a first capping layer and a first dielectric layer, filling the plurality of trenches with metal to form a plurality of spaced-apart metal lines, where the plurality of spaced-apart metal lines are situated in the first capping layer and the first dielectric layer, depositing a second capping layer directly on the first capping layer and over the plurality of spaced-

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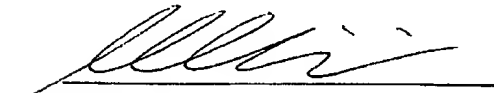
apart metal lines, and etching one or more air trenches into the damascene structure so that the air trenches are positioned between selected metal lines, as specified in amended independent claim 21. Thus, Jeng fails to cure the basic deficiencies of Buchwalter discussed above.

For the foregoing reasons, Applicants respectfully submit that the present invention, as defined by amended independent claim 21, is not taught, disclosed, or suggested by Buchwalter and Jeng, singly or in combination thereof. Thus, amended independent claim 21 is patentably distinguishable over Buchwalter and Jeng. As such, claims 22-28 depending from amended independent claim 21 are, *a fortiori*, also patentably distinguishable over Buchwalter and Jeng for at least the reasons presented above and also for additional limitations contained in each dependent claim.

E. Conclusion

Based on the foregoing reasons, the present invention, as defined by amended independent claims 1, 21, and 29, and claims depending therefrom, is patentably distinguishable over the art cited by the Examiner. Thus, claims 1-8 and 21-30 pending in the present application are patentably distinguishable over the art cited by the Examiner. As such, and for all the foregoing reasons, an early allowance of claims 1-8 and 21-30 pending in the present application is respectfully requested.

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Respectfully Submitted,  
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